

Exploratory and Confirmatory Factor Analysis: Understanding Concepts and Applications

by **Bruce Thompson**

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Exploratory and Confirmatory Factor Analysis: Understanding Concepts and Applications provides a concise (162 pages of text) and basic overview of two disciplines of assessing structure: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). As Thompson explains, the book was written “to strike a happy medium between accuracy and completeness versus overwhelming technical complexity” (p. ix). Example data sets are used throughout the book to demonstrate important concepts. It must be noted, however, that this is *not* a cookbook that presents analysis steps along with software syntax and output. Instead, the focus is on the explanation of concepts and the logic of EFA and CFA.

As the title implies, there is coverage of both EFA and CFA, but the majority of the book is dedicated to exploratory procedures. In addition, much of the discussion and demonstration of EFA focuses on the use of principal components (PC) analysis, which could be disappointing for those wanting a more detailed discussion of principal axis factor analysis (PAF).

The book consists of 12 chapters. Chapter 1 provides a very brief introduction to both EFA and CFA. The purposes of factor-analytic methods are succinctly presented, and the importance of theory when employing CFA is emphasized.

Chapter 2 introduces the basics of matrix algebra, major EFA concepts (e.g., pattern coefficients, structure coefficients, eigenvalues, number of factors), and the practical issue of sample size. A highlight of this chapter is the presentation of EFA concepts within the rubric of the general linear model and the emphasis on composite variables. By providing a quick introduction to matrix algebra concepts, Thompson hopes that readers “can have some understanding of what is being done in certain analyses” (p. 13). However, the coverage of matrix algebra concepts did not seem adequate to understand the formulas presented throughout the book. Given that the book was not meant to be overly technical, an appendix that more thoroughly introduces and explains the formulas by working through the examples would have been very useful. This would allow the reader uninterested in this level of detail to continue reading the body of the book, while allowing others to gain a better understanding of “what is being done in certain analyses” (p. 13). Currently, there is not enough detail for those unfamiliar with matrix algebra (which would seem to be a characteristic of the intended audience) to understand the formulas.

Chapter 3 clearly introduces the major decisions the researcher must make when conducting EFA. The type of matrix to analyze, the number of factors to extract and the guidelines for making this decision, the extraction method (PC vs. PAF), and factor rotation are all briefly described. The chapter ends with a short description of factor scores. A discussion of the appropriateness of

pairing an extraction method with particular procedures for determining the number of factors would have been useful (Benson & Nasser, 1998; Velicer, Eaton, & Fava, 2000).

Chapter 4, "Components Versus Factor Controversies," a very brief chapter of only 8 pages, introduces major issues discussed in the factor-analytic literature. More specifically, the bulk of the chapter discusses and demonstrates the *similarity* of the two analytic models (PC and PAF) and their outcomes (i.e., pattern coefficients, communalities). There was a nice, yet extremely short, section at the end of the chapter explaining why there are differences between the results produced by the two models. Overall, the chapter does an excellent job emphasizing that results can be similar across the two models, but it lacks a discussion centered on the *theoretical* differences between the analytic models and the impact of this difference on parameter estimates (see Snook & Gorsuch, 1989; Widaman, 1993). Most important, the chapter lacks a clear discussion concerning the choice of one model over the other (see Benson & Nasser, 1998; Fabrigar, Wegener, MacCallum, & Strahan, 1999; Preacher & MacCallum, 2003). It was somewhat disappointing that the author did not take the opportunity to summarize and explain the debate concerning the use of PC versus PAF (see *Multivariate Behavioral Research*, 25(1), for a discussion of components vs. common factor analysis).

Chapter 5 can be broken down into two sections. The first section focuses on factor scores. There is a demonstration of the equivalence of three factor score methods when PC is used as the extraction method and the nonequivalence when PAF is used as the extraction method; however, an explanation of why this occurs does not follow the example. Similarly, it is noted that the correlations of the factor scores when PC extraction is used will match the correlations among the factors themselves, but there is no discussion of this relationship when PAF is employed as the extraction method. This lack of explanation reduces the independence of the book, as readers must find other sources to fully understand these concepts. Further elaboration of these ideas and a more even discussion of both PC and PAF extraction would be extremely helpful for those new to EFA. The second section of the chapter provides an excellent demonstration of how one can use factor scores and variable responses to produce the structure/pattern weights, communalities, and eigenvalues. Thompson is clearly using the reader's knowledge of multiple regression to facilitate learning these new concepts; the demonstration is very clear. Unfortunately, the demonstration focuses solely on PC; there is no mention of the link between these ideas and PAF extraction. A novice is left asking if these properties just demonstrated with PC translate to other analytic methods. A discussion of the applicability of these ideas to other extraction methods would have provided the opportunity to further elaborate on similarities and differences between these two extraction methods.

Chapter 6 focuses on oblique factor solutions. The nonequivalence of the pattern and structure coefficients is clearly noted at the beginning of the chapter. A brief section highlights three issues to consider when selecting between an orthogonal factor solution versus an oblique factor solution: analytic purpose, parsimony, and interpretation difficulty. The chapter ends with a discussion and two examples of higher-order factor models. The Schmid and Leiman (1957) method for interpreting higher-order factor(s) is demonstrated (SPSS syntax and output is presented); however, a more detailed interpretation of the results would have been helpful (i.e., how is a value of .743 from the pattern product matrix interpreted?). It must be noted that PC extraction is used throughout this chapter; there is no discussion or examples that employ PAF extraction.

Chapter 7 briefly overviews Cattell's (1966) two-mode techniques. Chapter 8 introduces the idea of comparing different factor solutions to evaluate the degree of correspondence. An SPSS program is made available in the appendix to execute the "best-fit" factor rotation that enables the comparison of solutions. The chapter ends with some useful guidelines concerning the interpretation of factor solutions. Chapter 9 introduces and explains the important concept of sampling error.

The chapter emphasizes the need for replication to evaluate the generalizability of the sample solution. Cross-validation and bootstrap methods are demonstrated and clearly presented.

The last three chapters of the book (chapters 10-12) focus on CFA. The first of these chapters describes the process of conducting a basic CFA. The “preanalysis decisions” of specifying rival hypotheses, checking model identification, choosing a data matrix to analyze, screening data, and choosing an estimation method are covered first, followed by the “postanalysis decisions” of assessing model fit and diagnosing model misspecification. The chapter ends by advising readers to evaluate any post hoc modifications using an independent sample. This chapter provides an understandable, general overview of the issues and the major decisions associated with CFA.

Chapter 11 expounds on ideas introduced in the previous chapter. An example is used to illustrate the differences and similarities in results when employing different methods for setting the scale of the latent variables. The importance of reporting structure coefficients in conjunction with pattern coefficients is stressed and these values are reported for four different models that specify uncorrelated factors, correlated factors, correlated error variances, and multivocal items. An additional section interpreting the pattern and structure coefficients for each type of model would have been useful for novices. Model fit is discussed using an example involving four competing models. Those new to CFA may appreciate further discussion of how the models are nested. In addition, there was a lack of discussion of the use of standardized covariance residuals to diagnose model misfit; this would be useful as most researchers contend with misspecified models. The chapter ends with a brief discussion and demonstration of higher-order models. Similar to the discussion of higher-order models in chapter 6, relatively little attention is given to actually interpreting numeric values, which is disappointing given the introductory nature of the book.

The last of the three CFA chapters introduces invariance testing. Issues and major decisions surrounding the testing of model invariance (i.e., same number and type of factors) and unstandardized factor coefficient invariance across groups are presented, and the process is demonstrated using example data. Readers interested in the logic and process of invariance testing may be disappointed by the surface-level treatment of this topic.

In sum, this book provides a gentle, nontechnical introduction to the concepts associated with evaluating dimensionality. Thompson’s easy-to-read presentation style makes this book useful to graduate students or applied researchers who are interested in learning the basics of EFA and CFA. Because the book provides such a succinct overview of EFA and CFA concepts and their application, those seeking a more detailed, thorough introduction to EFA and CFA should consult the seminal, yet more technical, texts in these domains (e.g., Bollen, 1989; Gorsuch, 1983). This book could serve as a springboard to these more comprehensive texts.

Sara J. Finney
James Madison University

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Author's Address

Address correspondence to Sara J. Finney, Center for Assessment & Research Studies—MSC 6806, Department of Graduate Psychology, James Madison University, Harrisonburg, VA 22807; e-mail: finneysj@jmu.edu.